Furthermore, it is possible for testing and measuring purposes to generate inverse mode matrices that, for example, reduce the modes back into the antenna signals. This enables a combination network spatially integrated into an antenna arrangement, for example with an imaging unit that is designed for antenna signals and not for modes, to be checked.

Finally, it should be noted that both the costs for reception channels and the image reconstruction time play a critical role in the topic of the reduction of the image acquisition time via PAT measurement. For this reason, it is preferable to scale the number of the antenna signals that are read in corresponding to the current acceleration factor of a PAT measurement. This saves time, due to the lesser quantity of data that is to be read in, and expenses, since fewer reception channels are required. For this reason, in the reception unit the antenna signals are not directly directed to the reception channels of an imaging unit, but rather they are first supplied to a combination network. This combination network generates, for example, modes of the type that a number R of these modes are already sufficient given an acceleration factor R in order to operate parallel imaging. If a larger number of modes are used, this leads to a further local improvement in the signal-to-noise ratio in the MR exposure. In other words, the transmitted information is prepared, by the inclusion of the additional element combination network in the signal path, such that a scalability of the subsequently connected hardware and operating performance is possible.

Although modifications and changes may be suggested by those skilled in the art, it is the intention of the inventors to embody within the patent warranted hereon all changes and modifications as reasonably and properly come within the scope of their contribution to the art.

WE CLAIM AS OUR INVENTION:

1. A method for forming at least two modes for a magnetic resonance imaging apparatus from at least two magnetic resonance response signals respectively with at least two local antennas, comprising the steps of:

generating a primary mode by combining said magnetic resonance response signals in a first weighted linear combination, said primary mode corresponding to a magnetic resonance signal of an amplitude-controlled and phase-controlled group antenna exhibiting a first sensitivity distribution that is optimized for a target region within a detection volume of said local antennas; and

generating a secondary mode by combining said response signals in a second weighted linear combination, said secondary mode corresponding to a magnetic resonance signal of an amplitude-controlled and phase-controlled group antenna exhibiting a second sensitivity distribution that is different from said first sensitivity distribution in a phase coding direction of said response signals.

2. A method as claimed in claim 1 comprising generating said primary mode using said first weighted linear combination with a linear coefficient dependent on a geometric position of said local antennas relative to said target region.

3. A method as claimed in claim 1 comprising generating said primary mode with said first weighted linear combination having respective factors, selected from the group consisting of weighting factors and phase factors, applied to the respective signals from the local antennas, representing an influence of the target

region on that local antenna selected from the group consisting of a distance of that local antenna from the target region and an angle of that local antenna relative to the target region.

4. A method as claimed in claim 1 comprising generating said primary mode with said first weighted linear combination having respective phase factors applied to said response signals representing a sensitivity of the local antenna, from which the respective response signal was received, in the target region relative to a phase of the magnetic resonance emission from said target region.

5. A method as claimed in claim 1 comprising generating a magnetic resonance image, exhibiting a signal-to-noise ratio, from said primary mode, and employing at least one coefficient in said first linear weighted combination that optimizes said signal-to-noise ratio of said image in said target region.

6. A method as claimed in claim 5 wherein said target region is a first target region, and comprising employing at least one coefficient in said second weighted linear combination so that a parallel imaging implemented with said primary mode and said secondary mode, with an acceleration factor of two, optimizes the signal to noise ratio in said image in a second target region.

7. A method as claimed in claim 1 comprising receiving at least three magnetic resonance response signals respectively from at least three local antennas, and comprising the additional step of generating a tertiary mode from a

third weighted linear combination of said response signals, said tertiary mode corresponding to a magnetic resonance signal of an amplitude-controlled and phase-controlled group antenna that exhibits a third sensitivity distribution, that is different from said first sensitivity distribution and said second sensitivity distribution in said phase-coding direction.

8. A method as claimed in claim 7 comprising employing at least one coefficient in said third weighted linear combination that optimizes a signal-to-noise ratio in a further target region, different from said target region, in an image produced by parallel imaging with said primary, secondary and tertiary modes with an acceleration factor of 3.

9. A method as claimed in claim 7 comprising selecting a preliminary secondary mode and a preliminary tertiary mode that are orthogonal to each other and orthogonal to said primary mode, and generating said secondary mode as a linear combination of said preliminary secondary mode and said preliminary tertiary mode, to optimize a signal-to-noise ratio in a further target region, different from said target region, in an image produced by parallel imaging with said primary mode and said secondary mode with an acceleration factor of two.

10. A method as claimed in claim 1 comprising generating at least four magnetic resonance response signals from a number of local antennas that is at least four, up to a number of response signals equal to said number of local antennas, and for each additional response signal, forming one further mode by a

further linear combination of said response signals, each further mode exhibiting a sensitivity distribution that is different from the respective sensitivity distributions of each of the other modes.

11. A method as claimed in claim 10 wherein at least two of said modes are orthogonal relative to each other.

12. A method as claimed in claim 1 comprising generating at least four magnetic resonance response signals from a number of local antennas that is at least four, up to a number of response signals equal to said number of local antennas, and for each additional response signal, forming one further mode by a further linear combination of said response signals, each further mode optimizing a signal-to-noise ratio in a selected further target region, different from said target region, in an image obtained by parallel imaging with all of said modes with an acceleration factor corresponding to the number of said modes.

13. A method as claimed in claim 12 wherein at least two of said modes are orthogonal relative to each other.

14. A method as claimed in claim 1 comprising selecting a region of interest in a magnetic resonance examination as said target region.

15. A method as claimed in claim 1 wherein said at least two local antennas form an antenna arrangement having a field of view defining a detection

volume in an examination subject, and comprising selecting a region in said detection volume as said target region that, due to said antenna arrangement, exhibits a lower sensitivity in at least one of said first and second sensitivity distributions.

16. A method as claimed in claim 1 comprising selecting said target region by selecting at least one coefficient in at least one of said first weighted linear combination and said second weighted linear combination.

17. A method for providing modes for magnetic resonance imaging in a magnetic resonance imaging apparatus, comprising the steps of:

providing at least two local antennas having, in combination, a field of view that defines a detection volume of an examination subject, and substantially simultaneously receiving one magnetic resonance response signal with each of said local antennas, said response signal comprising signal components that are spatially associated with respective regions in said detection volume;

generating a primary mode by combining said magnetic resonance response signals in a first weighted linear combination, said primary mode corresponding to a magnetic resonance signal of an amplitude-controlled and phase-controlled group antenna exhibiting a first sensitivity distribution that is optimized for a target region within said detection volume of said local antennas;

generating a secondary mode by combining said response signals in a second weighted linear combination, said secondary mode corresponding to a magnetic resonance signal of an amplitude-controlled and phase-controlled group antenna exhibiting a second sensitivity distribution that is different from said first sensitivity distribution in a phase coding direction of said response signals; and

supplying at least one of said primary mode and secondary mode to a reception channel of a magnetic resonance imaging unit.

18. A method as claimed in claim 17 comprising supplying said primary mode to said reception channel and processing said primary mode in said imaging unit to generate a magnetic resonance image.

19. A method as claimed in claim 17 comprising supplying said primary mode to a first reception channel in said imaging unit and supplying said secondary mode to a second reception channel in said imaging unit, processing said primary mode in said imaging unit to generate a first magnetic resonance image including said target region, and processing said primary and secondary modes in said imaging unit with a parallel imaging technique to generate a second magnetic resonance image including said target region.

20. A method as claimed in claim 19 comprising providing at least three local antennas, each receiving said response signal, and generating a tertiary mode with a third weighted linear combination of the respective response signals received

by said three antennas, said tertiary mode corresponding to a magnetic resonance signal of an amplitude-controlled and phase-controlled group antenna exhibiting a third sensitivity distribution that is different from said first sensitivity distribution and said second sensitivity distribution in said phase coding direction, and processing said primary, secondary and tertiary modes in said imaging unit using a parallel imaging technique to generate a third magnetic resonance exposure including said target region.

21. A method as claimed in claim 20 comprising providing at least four local antennas, each receiving said response signal, and generating at least one further mode with a further linear combination of the response signals respectively received by said at least four local antennas, said at least one further mode exhibiting a sensitivity distribution that is different from the respective sensitivity distributions of all other modes, and processing all of said modes in said imaging unit in respective reception channels, using a parallel imaging technique, to generate a further magnetic resonance exposure including said target region.

22. A reception unit for a magnetic resonance imaging apparatus, comprising:

at least two local antennas; and

a combination network to which said at least two local antennas are separately connected, said combination unit generating at least two different modes from respectively different linear combinations of antenna signals respectively received by said at least two local antennas, said combination network having at least two outputs at which at least two of said at least two different modes are respectively present.

23. A reception unit as claimed in claim 22 wherein said combination unit produces said at least two modes with respectively different sensitivity distributions that differ in a phase coding direction.

24. A reception unit as claimed in claim 22 wherein said combination network applies a linear coefficient to one of said antenna signals, in said linear combination.

25. A reception unit as claimed in claim 24 wherein said combination unit employs a quantity selected from the group consisting of weighting factors and phase shifts, as said linear coefficient.

26. A reception unit as claimed in claim 22 wherein said combination unit generates one of said modes as a mode corresponding to a signal of an antenna having a geometry to receive a spatial field structure that is not individually receivable with any one of said local antennas.

27. A reception unit as claimed in claim 22 wherein the respective signals from the local antennas exhibit different run-times, and wherein said combination unit comprises at least one phase shifter for compensating for said run time differences.

28. A reception unit as claimed in claim 22 wherein said combination network comprises a signal combination unit having two inputs and two outputs, with respective signals from said at least two antennas being supplied to respective inputs, the signals at the respective inputs being added with a first linear coefficient without a phase difference to produce a signal at one of said outputs and being added with a second linear coefficient with a phase difference to produce a signal at the other of said outputs.

29. A reception unit as claimed in claim 28 wherein said phase difference is selected from the group consisting of 60°, 90°, 120° and 180°.

30. A reception unit as claimed in claim 22 comprising at least three local antennas and wherein said combination network comprises a first signal combination unit having two inputs and two outputs at a second signal combination unit having two inputs and two outputs, with two of the antenna signals respectively from said at least three local antennas being supplied to the respective inputs of the first signal combination unit, a first of said outputs of said first signal combination unit being connected to an output of said combination network at which a first of said modes is present, and a second of said outputs of said first signal combination unit being connected with a first of the inputs of the second signal combination unit, and a third of said antenna signals of said at least local antennas being supplied to a second of the inputs of said second signal combination unit, and a first of the outputs of said second signal combination unit being connected with a further output of said combination network at which a second of said modes is present.

31. A reception unit as claimed in claim 30 wherein a second of the outputs of said second signal combination unit is connected to a third output of the combination network.

32. A reception unit as claimed in claim 30 wherein said at least three local antennas include two laterally arranged local antennas, the respective signals received thereby being supplied to the first and second of the inputs of said first signal combination unit and a third local antenna disposed between the laterally arranged local antennas, said third antenna generating said third antenna signal, and wherein said first signal combination unit adds the respective signals of said two laterally arranged local antennas with a weighting factor of $2^{-1/2}$ without a phase difference to produce a secondary mode and adds the signals of the two laterally arranged local antennas with a weighting factor of $2^{-1/2}$ and with a phase difference of 180° to produce said signal at the second of the outputs of said first signal combination unit, and wherein said second signal combination unit adds the signal from the second of the outputs of said first signal combination unit with said third antenna signal from said third local antenna with a weighting factor of $2^{-1/2}$ and with a phase difference of 90° and a weighting factor of $2^{1/2}$, to generate a tertiary mode, and adds said signal from the second of the outputs of said first signal combination unit with said third antenna signal from said third local antenna with a phase difference of -90° to generate a primary mode.

33. A reception unit as claimed in claim 30 wherein said at least three local antennas include two laterally arranged local antennas, the respective signals

received thereby being supplied to the first and second of the inputs of said first signal combination unit and a third local antenna disposed between the laterally arranged local antennas, said third antenna generating said third antenna signal, and wherein said first signal combination unit adds the respective signals of said two laterally arranged local antennas with a weighting factor of $2^{-1/2}$ and with a phase difference of 60° to produce a secondary mode and adds the signals of the two laterally arranged local antennas with a weighting factor of $2^{-1/2}$ and with a phase difference of 120° to produce said signal at the second of the outputs of said first signal combination unit, and wherein said second signal combination unit adds the signal from the second of the outputs of said first signal combination unit with said third antenna signal from said third local antenna with a phase difference of 60° and a weighting factor of $2^{1/2}$, to generate a primary mode, and adds said signal from the second of the outputs of said first signal combination unit with said third antenna signal from said third local antenna with a weighting factor of $2^{-1/2}$ and with a phase difference of 120° to generate a tertiary mode.

34. A reception unit as claimed in claim 30 wherein said first and second signal combination units are substantially reflection-free.

35. A reception unit as claimed in claim 30 wherein said first and second signal combination units are substantially lossless.

36. A reception unit as claimed in claim 30 wherein one of said first and second signal combinations is a hybrid unit.

37. A reception unit as claimed in claim 36 wherein said hybrid unit is a four-port coupler.

38. A reception unit as claimed in claim 22 wherein at least one of said outputs of said combination network is connected to a reception channel of a local antenna selection unit.